

High Energy and Nuclear Physics (HENP)

Regina Rameika, Associate Director,
Office of High Energy and Nuclear Physics

DPF/DNP Community Meeting
May 22, 2026

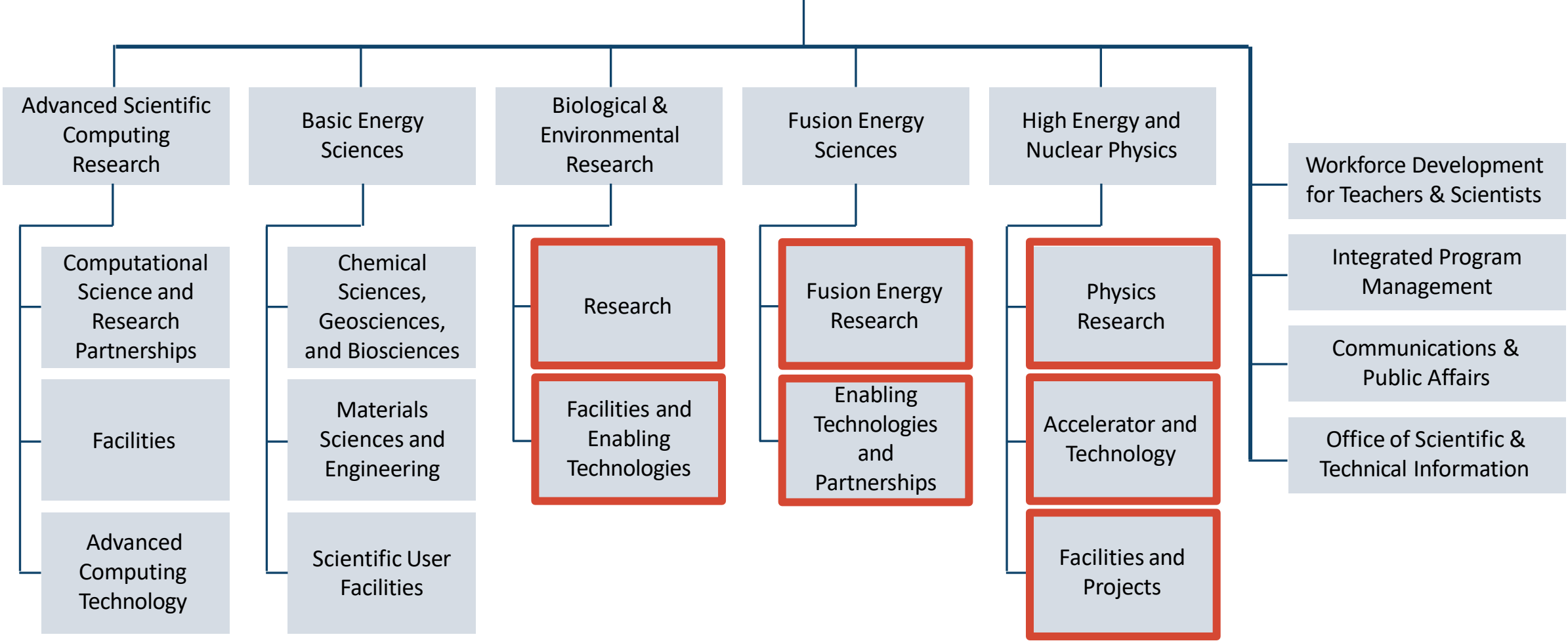


U.S. DEPARTMENT
of **ENERGY**

Office of
Science

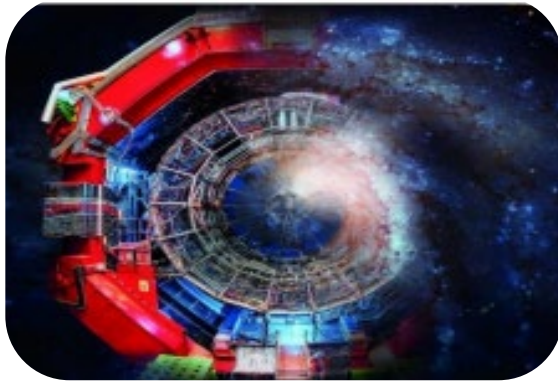
[Energy.gov/science](https://www.energy.gov/science)

Deputy Director for Science Programs

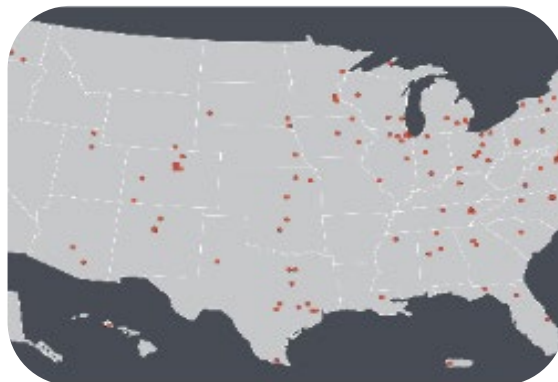


Office of High Energy Physics at a Glance

FY 2026 Enacted: \$1.235B



As the largest funder of particle physics in the U.S. (~85%), HEP also supports international experiments in Canada, Chile, Japan, and Switzerland



Funding at **12** DOE National Labs, and **>175** Academic Institutions, Small Businesses, Non-Profits, and Other Federal Agencies



Snowmass 2022
1,003 Ph.D. Scientists and **448** Grad Students Supported



HEP supports **3** SC User Facilities and **2387** Users at BNL, FNAL, and SLAC



~**30%** of Research to Universities



Research: **35%**, **\$430.6M**



VCR Operations in Chile
Facility Operations: **32%**, **\$392.1M**



Outfitting of DUNE caverns at SURF for first far detector cryostat
Projects: **33%**, **\$412.4M**



Office of Nuclear Physics at a Glance

Mission: Discover, explore, and understand all forms of nuclear matter.

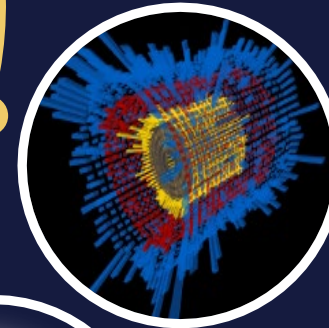
Seeks to understand **subatomic matter**, including exotic matter inside neutron stars and in the early days of the universe, **and how that knowledge can benefit society (critical technologies, medicine, and national security).**



Largest supporter (>95%) of U. S. nuclear physics research
FY 2026 Enacted \$866.141M



Supports over **1,400 Ph.D. staff** and **720 graduate students**
FY 2026 Research: 23%



Stewardship of **4 SC User Facilities: ATLAS, CEBAF, and FRIB, and RHIC**
FY 2026 Operations: 57%
>4,000 users annually



In construction: Electron-Ion Collider will probe the inside of the proton
FY 2026 Construction: 20%





Regina Rameika, Associate Director (Acting)

Associate Director's Office Staff
Dannette Keen, Financial Management Analyst
Linnette Quick, Program Assistant (CONTR)

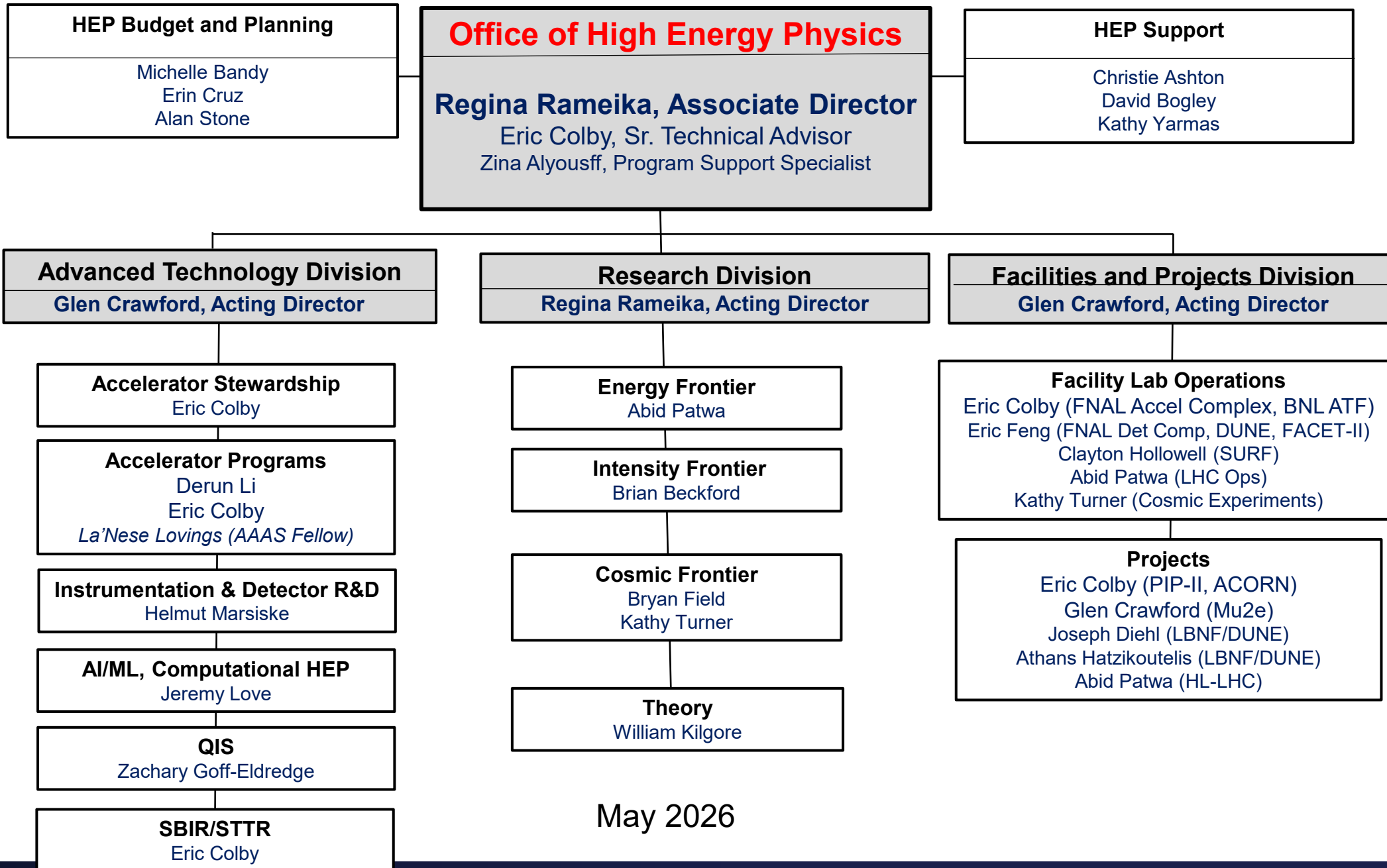
Physics Research Division
Sharon Stephenson, Director
Saryna Cameron, Program Support Specialist (CONTR)

Facilities & Project Management Division
Paul Mantica, Director
Saryna Cameron, Program Support Specialist (CONTR)

- Heavy Ion Nuclear Physics**
Spyridon Margetis
- Medium Energy & Quantum Information Science**
Gulshan Rai, Technical Advisor
- Nuclear Structure & Nuclear Astrophysics**
Spyridon Margetis
- Nuclear Theory**
Astrid Morreale
- Nuclear Data**
Keith Jankowski
- Fundamental Symmetries**

- Advanced Technology R&D**
Vacant
- Nuclear Physics Facilities**
Manouchehr Farkhondeh
- Nuclear Physics Major Initiatives**
Ivan Graff
- Nuclear Physics Instrumentation**
Elizabeth Bartosz
- Industrial Concepts**
Michelle Shinn





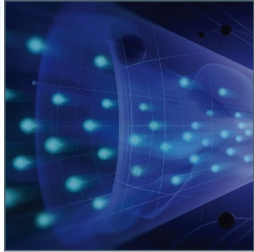
May 2026



HEP research answers fundamental questions while developing breakthrough technologies

Particle Physics Research

- High Energy Physics explores what the world is made of and how it works at the smallest and largest scales, seeking new discoveries from the tiniest particles to the outer reaches of space.



Decipher the Quantum Realm

Elucidate the Mysteries of Neutrinos

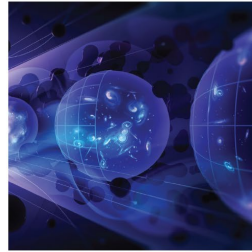
Reveal the Secrets of the Higgs Boson



Explore New Paradigms in Physics

Search for Direct Evidence of New Particles

Pursue Quantum Imprints of New Phenomena



Illuminate the Hidden Universe

Determine the Nature of Dark Matter

Understand What Drives Cosmic Evolution

Accelerator Research and Stewardship

- HEP develops new accelerator, detector, and computational tools to open new doors to discovery science,
- Through Accelerator Stewardship, HEP works to make transformational accelerator technology widely available to science and industry.



Emerging Technology Research

HEP research is inspired by some of the biggest questions about our universe.

- Finding these answers requires development of state of the art detectors using cutting edge technologies
- Technology development inspires young minds, trains an expert workforce, and drives innovation that improves the nation's health, wealth, and security.



NP Avenues for Discovery

Probing Proton Substructure

Reveals dynamics, structure, and spin for protons and neutrons

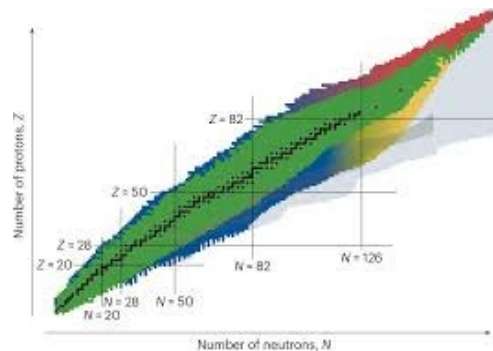
- ◆ Heavy ion collisions and electron scattering informs our understanding of nuclear phenomena and the formation of the universe
- ◆ U.S. provides the **world's highest intensity, polarized** electron beams for this science



Exploring the Isotope Landscape

Enables element and isotope discovery

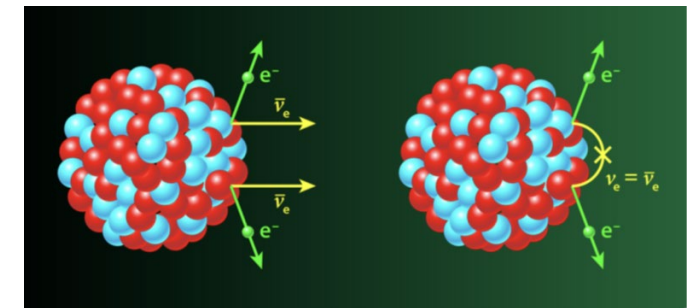
- ◆ Reaction rates and structure data for national priorities
- ◆ Superheavy elements provide a fertile ground for tests of theory
- ◆ **Nuclear data** and capabilities for characterization of electronics (e.g., defects, radiation-induced failures)



Studying Rare Decays

Targets natural processes that break conservation laws and symmetries

- ◆ **Data-driven science** to explain the matter-antimatter balance
- ◆ Extreme high-precision detectors translate to other applications
- ◆ Nuclear-science-based innovation for **Quantum Information Science**

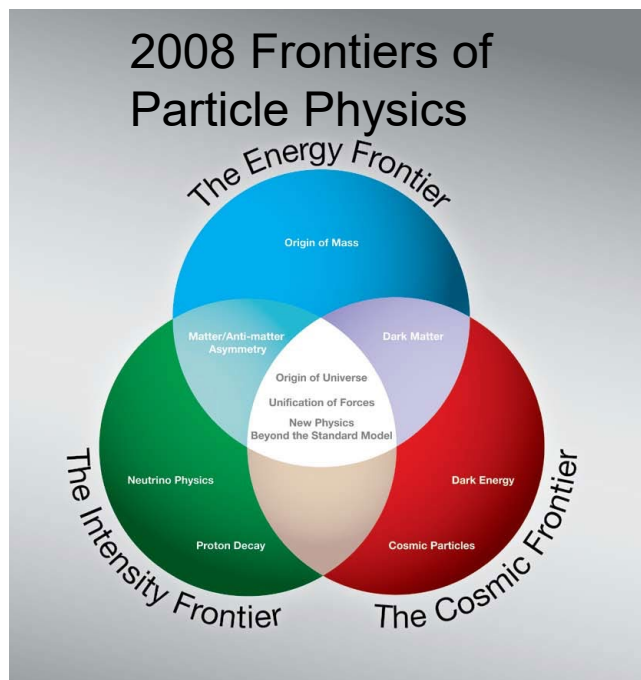


Crosscutting: Theory, AI, Advanced Computing, Accelerator & Detector R&D



U.S. Particle Physics roadmap comes from a Strategic Planning Process

2008 Frontiers



2014 Science Drivers

	Energy Frontier	Intensity Frontier	Cosmic Frontier
Higgs Boson	●		
Neutrino Mass		●	●
Dark Matter	●	●	●
Cosmic Acceleration			●
Explore the Unknown	●	●	●

2023 Science Drivers

Exploring the Quantum Universe

- Reveal the Secrets of the Higgs Boson**
 Elucidate the Mysteries of Neutrinos
- Decipher the Quantum Realm**
- Determine the Nature of Dark Matter**
 Understand What Drives Cosmic Evolution
- Illuminate the Hidden Universe**
- Search for Direct Evidence of New Particles**
 Pursue Quantum Imprints of New Phenomena
- Explore New Paradigms in Physics**

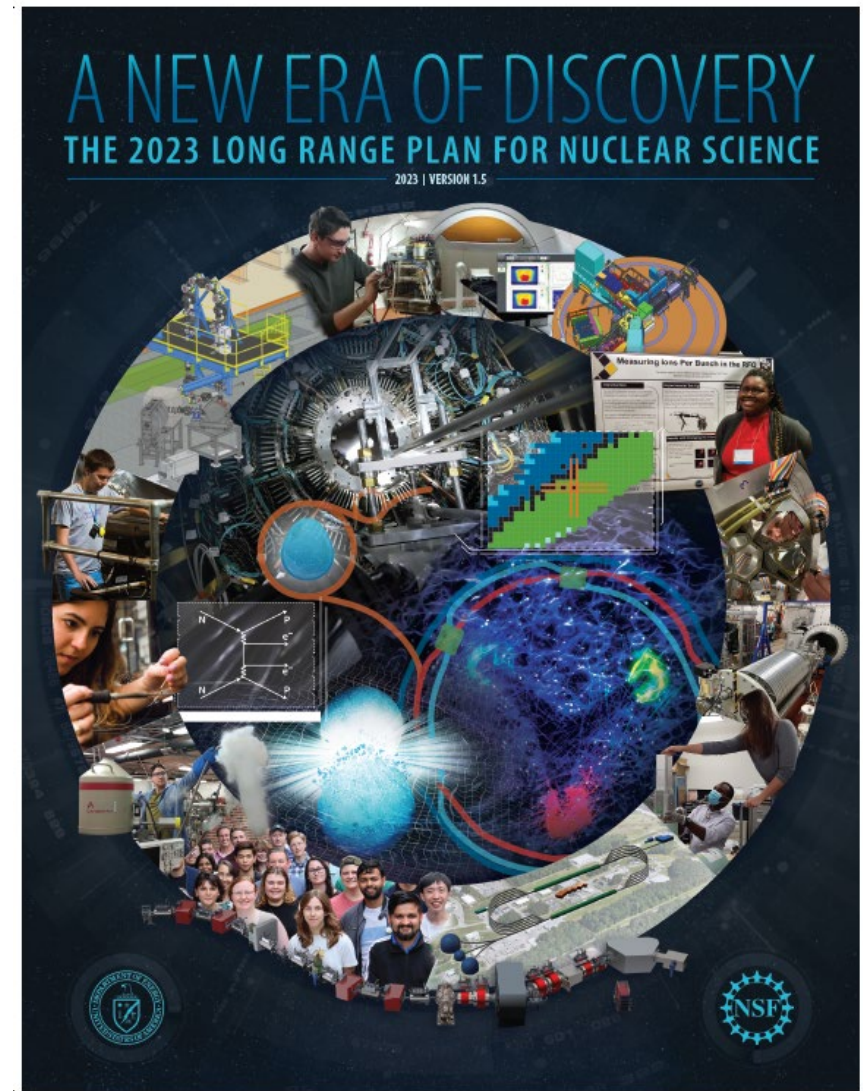


NP Priorities Build on a Community Vision for A New Era of Discovery

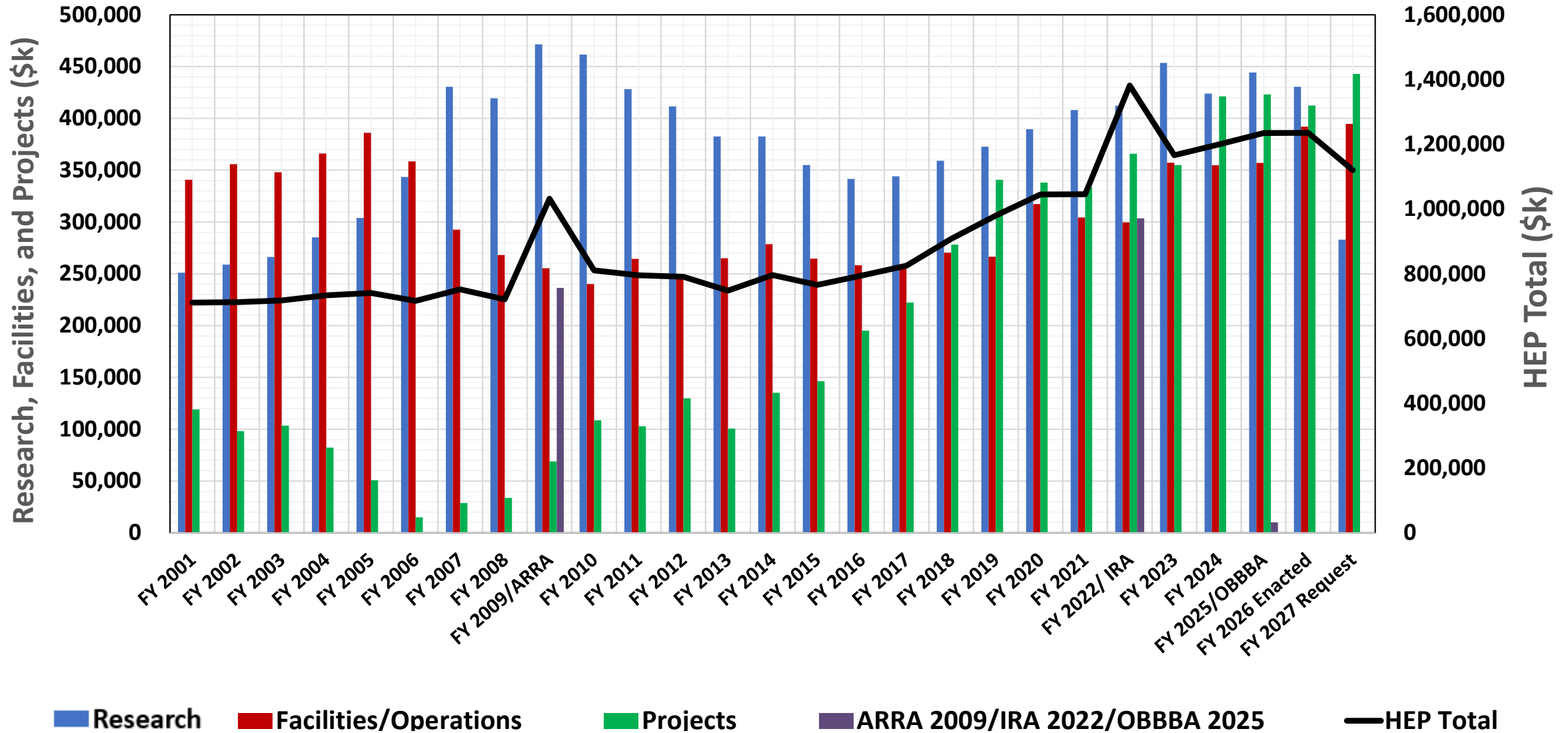
The DOE-NSF Nuclear Science Advisory Committee brought the community together to plan the future of Nuclear Physics Research for the Nation.

Increase research and grow subject matter expertise to capitalize on the extraordinary opportunities for scientific discovery made possible by the substantial and sustained investments of the United States.

We reaffirm the exceptionally high priority of the following two investments in new capabilities for nuclear physics. The **Electron-Ion Collider (EIC)**, ...will elucidate the origin of visible matter in the universe and significantly advance accelerator technology... **Neutrinoless double beta decay experiments** have the potential to dramatically change our understanding of the physical laws governing the universe.



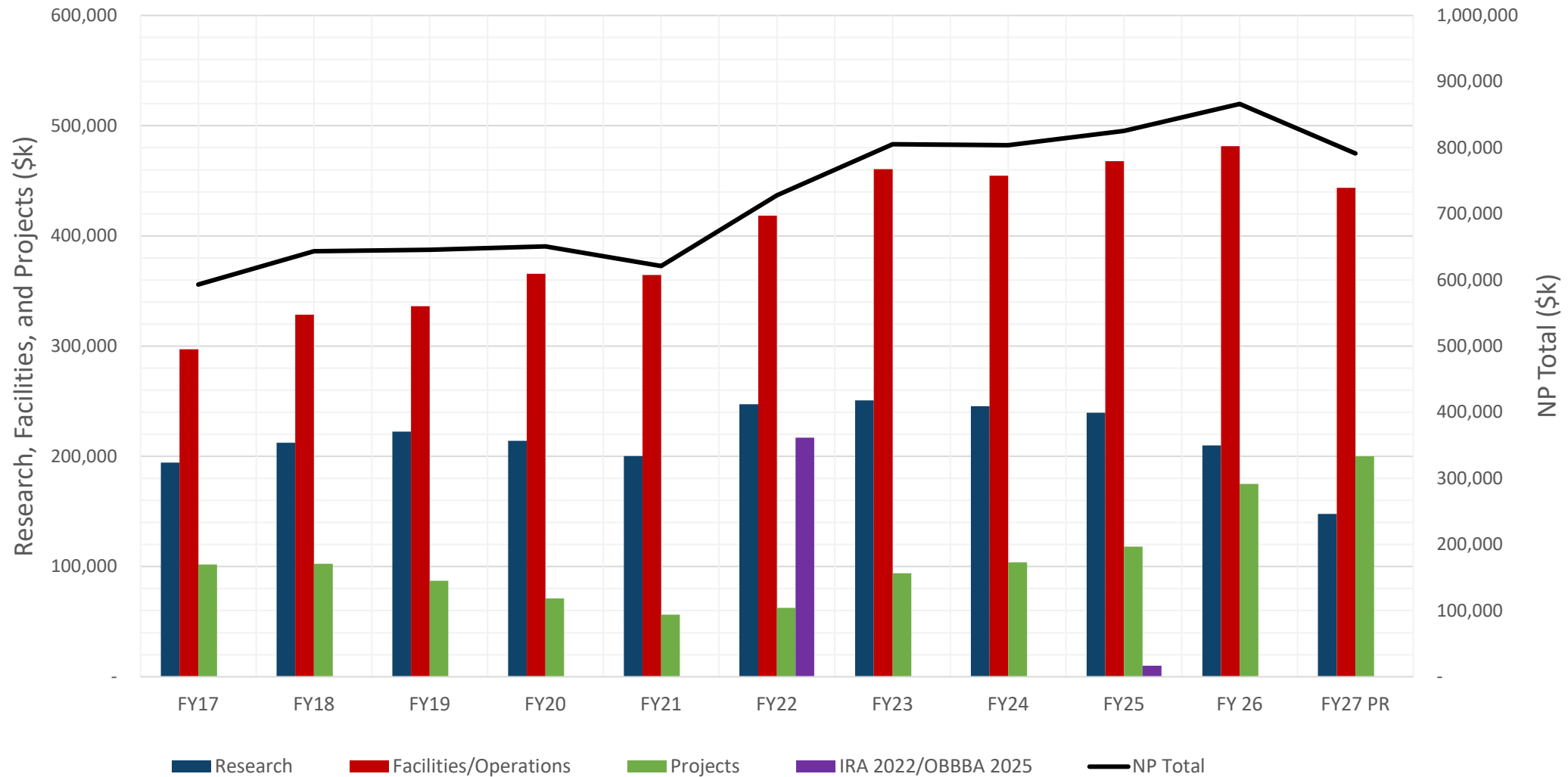
HEP Budget (\$K): Research, Facilities, & Projects



ARRA 2009 funds supported Research, Facilities, and Projects
 IRA 2022 funds supported Projects only
 One Big Beautiful Bill Act (OBBA) of FY 2025 funds Research only
 Beginning FY 2026: formerly ARDAP program funds are merged into the HEP Budget



NP Budget (\$K): Research, Facilities & Projects



HEP Construction Projects

5 sub-projects



Project	Location	Current CD	Project Cost	Next CD	CD-4 baseline date
Mu2e	FNAL	CD-3	\$316M	CD-4	Q2FY28
PIP-II	FNAL	CD-3	\$978M	CD-4 (Q2FY30)	Q1FY33
HL-LHC AUP	FNAL	CD-3	\$266M	CD-4 (Q1FY28)	Q1FY30
HL-LHC ATLAS	BNL	CD-3	\$200M	CD-4 (Q3FY29)	Q1FY31
HL-LHC CMS	FNAL	CD-3	\$200M	CD-4 (Q4FY29)	Q1FY31
LBNF/DUNE: FSCF-EXC	FNAL	CD-3	\$644M	CD-4	Q4FY26
LBNF/DUNE: FSCF-BSI	FNAL	CD-3	\$211M	CD-4	Q4FY28
LBNF/DUNE: FDC	FNAL	CD-3c	\$1119M	CD-2/3 (FY26 Q3)	Q1 FY33
LBNF/DUNE: NSCF +Beam	FNAL	CD-3a	\$1103M	CD-2/3 (FY27)	Q1 FY32
LBNF/DUNE: ND	FNAL	CD-1RR	\$200M	CD-2/3 (FY27)	Q1 FY35



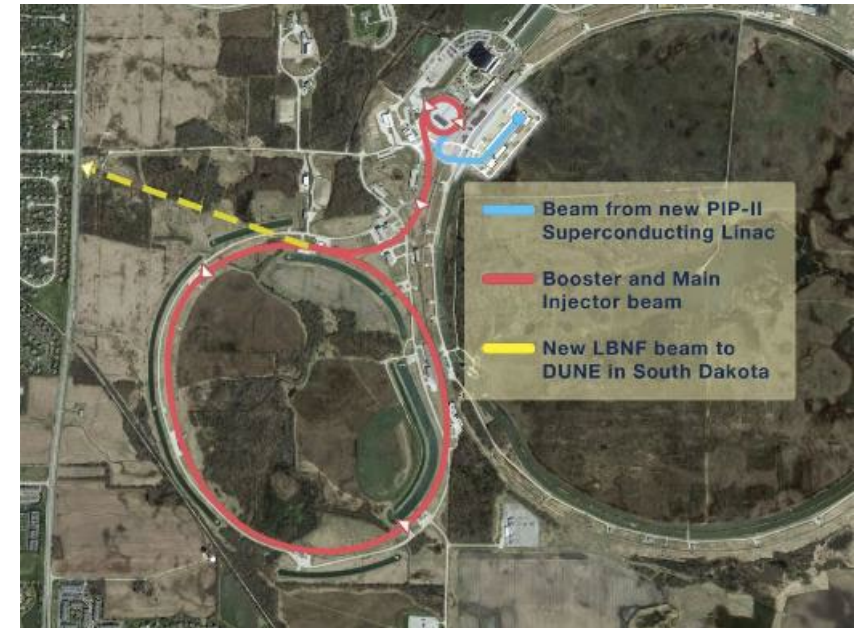
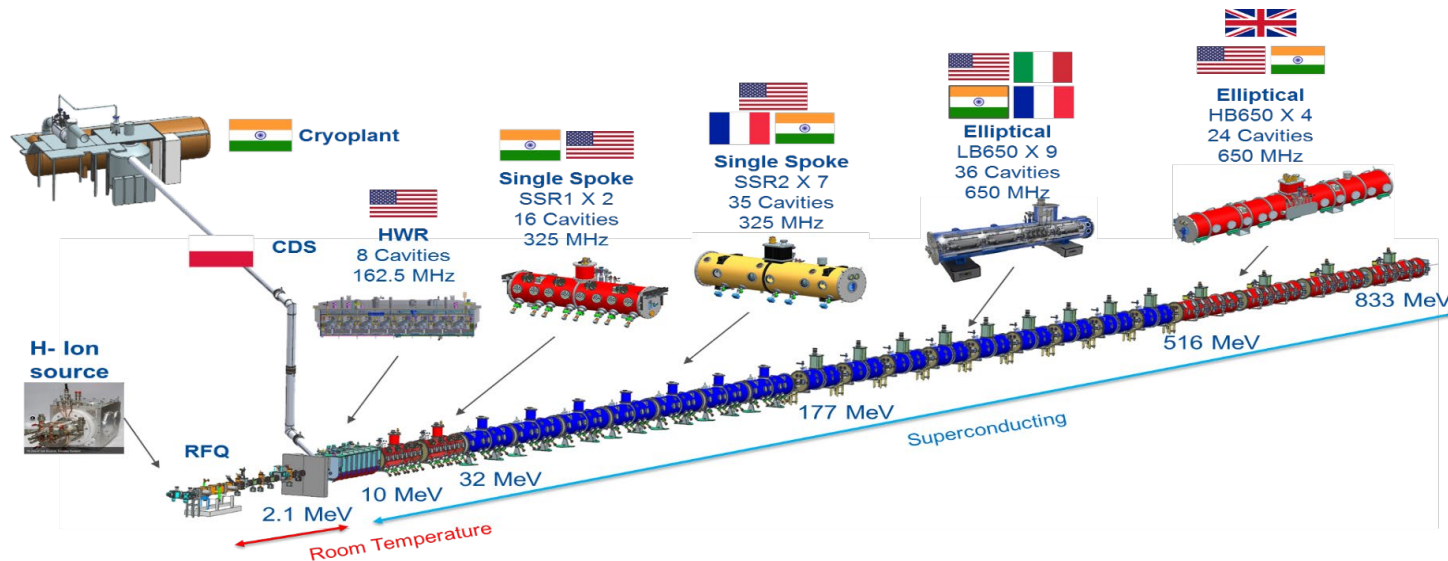
NP Projects Status

Project	Location	Status	Cost	CD-4
Construction Projects				
Electron-Ion Collider (EIC)	BNL	CD-3B	\$1.7B to \$2.8B (Est)	Q1 FY36 (Est)
Major Items of Equipment				
Gamma Ray Energy Tracking Array (GRETA) <small>Fully Funded, Delegated</small>	LBNL	CD-4A	\$58.3M (TPC)	Q2 FY28
Measurement of a Lepton-Lepton Electroweak Reaction (MOLLER) <small>Fully Funded</small>	TJNAF	CD-2/3	\$48.66M (TPC)	Q4 FY28
High Rigidity Spectrometer (HRS)	MSU			
High Transmission Beam Line (HTBL)		CD-2/3	\$49.7M (TPC)	Q3 FY30
Spectrometer Section (SPS)		CD-1	\$65.5M - \$87.3M (Est)	Q2 FY32 (Est)
Ton Scale Neutrinoless Double Beta Decay (TS-NLDBD) Near-term LEGEND-1000	ORNL	CD-0	\$409M to \$665M (Est)	TBD



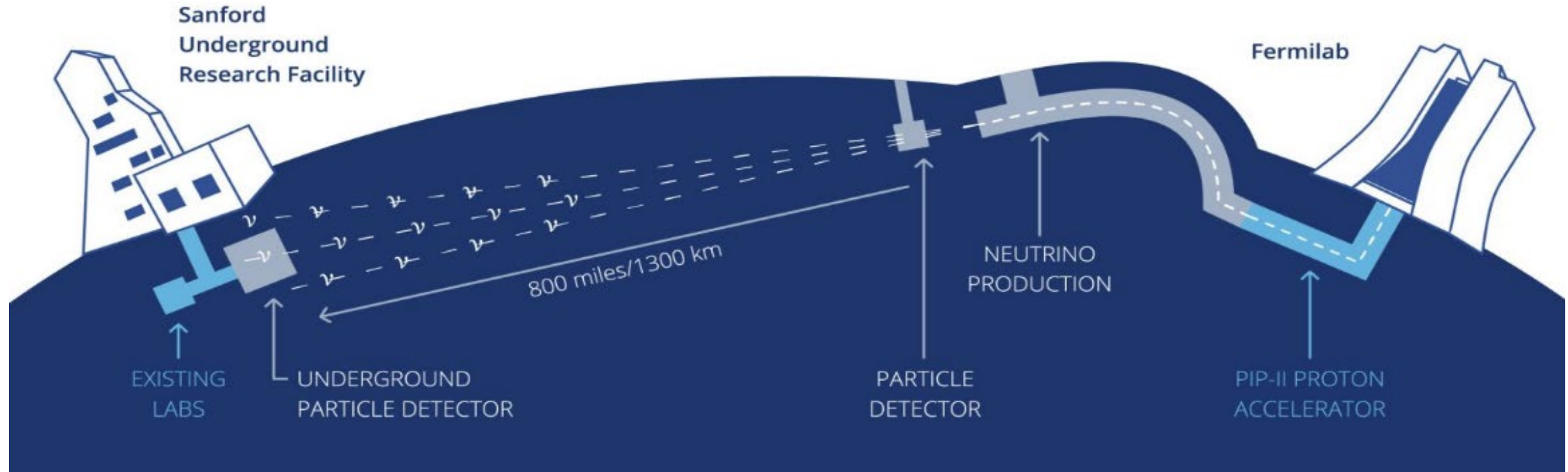
PIP-II Construction Project

- New Superconducting Linac will replace Fermilab's 50-year-old front-end infrastructure, increasing beam power, energy, reliability, flexibility and upgradability.
- Extends Fermilab's leadership with world's most intense neutrino beam for long baseline experiment and other scientific opportunities.
- DOE Total Project Cost = \$978 M
 - CD-3 4/18/2022 Approved Start of Construction
 - CD-4 1Q FY 2033 Forecast for Project Completion



LBNF/DUNE Construction Project

U.S. Project Scope Delivered at Two Sites through Six Subprojects



Three subprojects

- ◆ **FSCF-EXC** - Far Site Excavation
- ◆ **FSCF-BSI** - Far Site Building & Site Infrastructure
- ◆ **FDC** - Far Detectors and Cryogenic Infrastructure

Two → Three subprojects

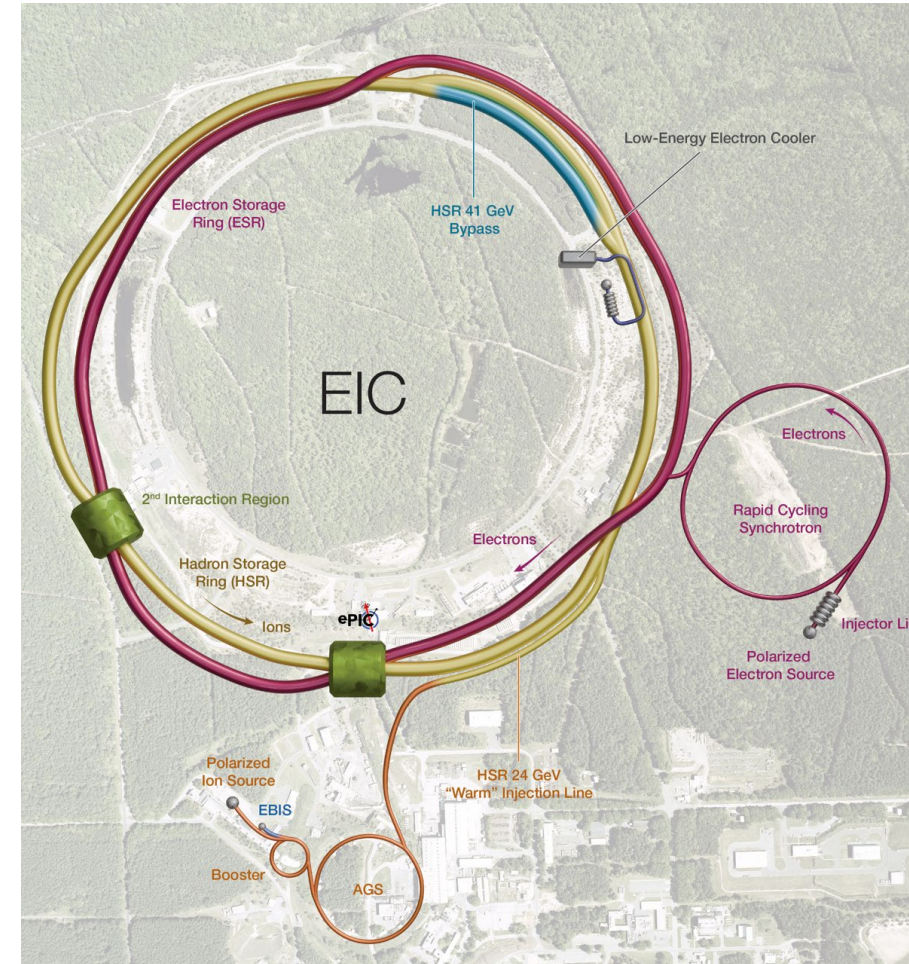
- ◆ **NSCF** - Near Site Conventional Facilities
 - ◆ **B** - Beamline
 - ◆ **ND** - Near Detectors
- Currently together

Largest **DOMESTIC** project in Office of Science (TPC = \$3.3B)



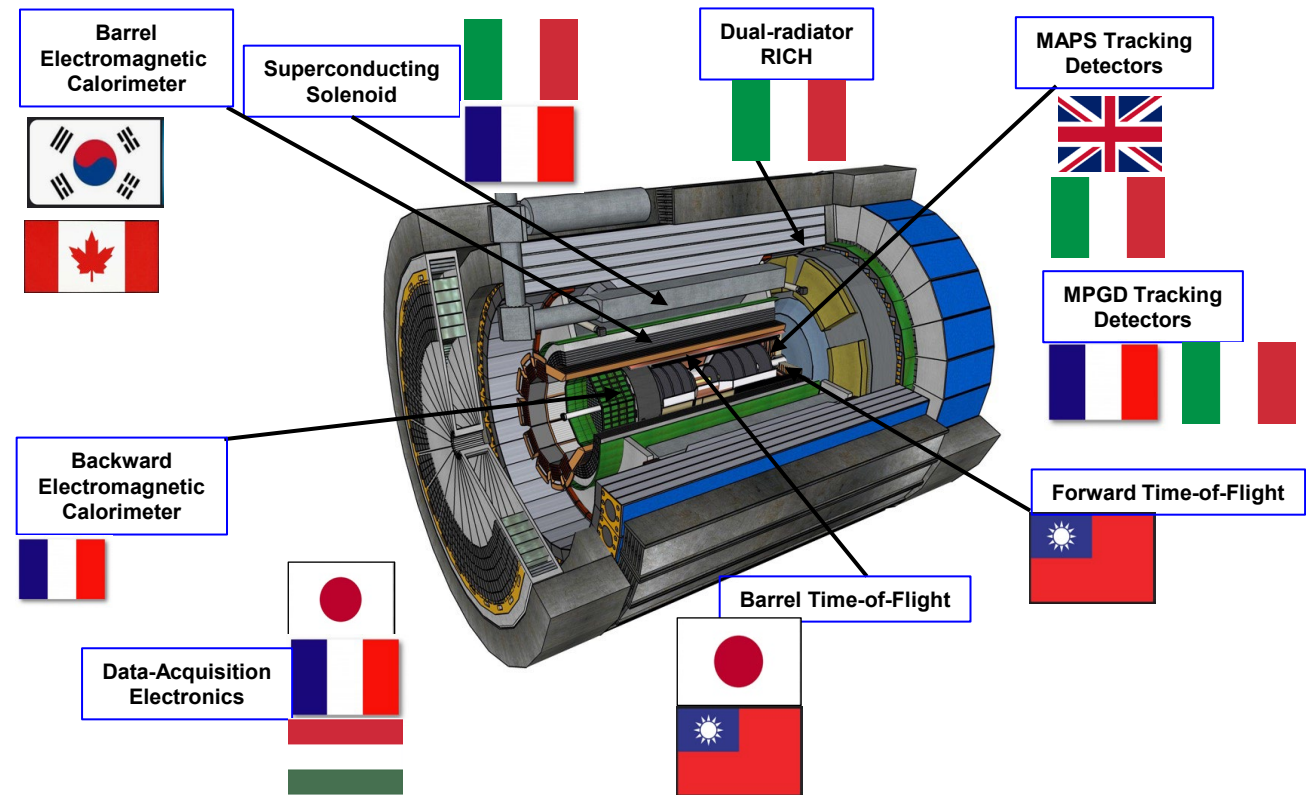
Electron-Ion Collider: Top Priority for New Facility Construction in the Nuclear Science Long Range Plan

- Located at BNL, using existing RHIC assets, with TJNAF as a major partner
- Estimated cost range of \$1.7 billion to \$2.8 billion.
- In-kind contributions: New York State and International partners
 - \$100M grant from New York supports civil construction
 - ~\$90M anticipated for the detector ePIC (~30%)
 - ~\$50M anticipated accelerator scope (~5%)
- Critical Decision-3A (long lead procurement): March 2024
- Critical Decision CD-3B (second long lead procurement request) approved January 2026
- Project elaborating its subproject strategy



NP International Engagement Continues to Grow

- ◆ Topics of mutual interest:
 - Alignment with NP mission and scope.
 - Alignment with mission and scope of international partners.
 - Capabilities of the participating international partners.
- ◆ EIC User Group: 1,562 members from 310 Institutions in 41 countries (March 2026)



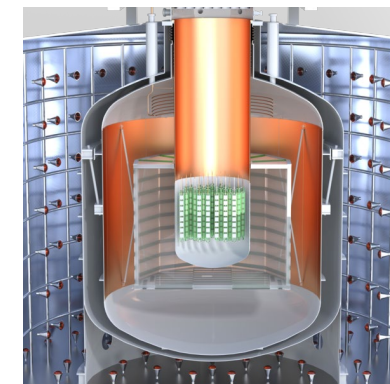
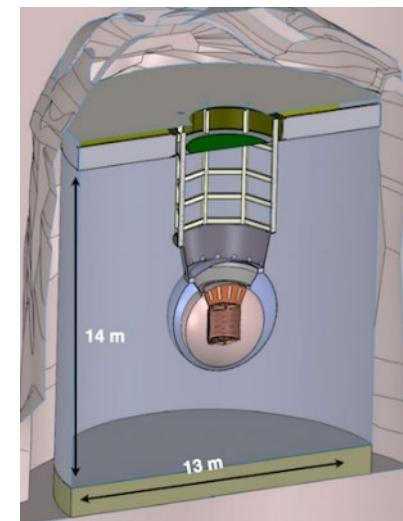
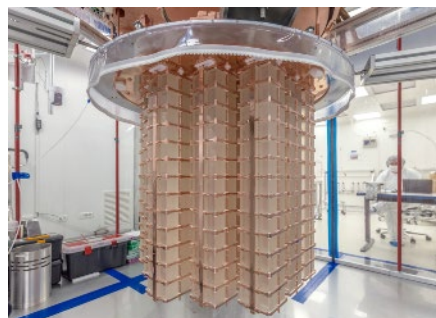
- ◆ Expressed interests in the ePIC central detector subsystems labeled by country

Neutrinoless Double Beta Decay: Top Priority for New Experiment Construction in the Nuclear Science Long Range Plan

- ◆ Roughly \$20.0M has been allocated since 2020 to explore three technologies: CUPID, LEGEND-1000, nEXO, and; supporting conceptual design and R&D.
- ◆ **In December 2024, LEGEND-1000 selected as the first priority for NP investment.** (est. cost \$500 M)
- ◆ A multi-pronged campaign to detect neutrinoless double beta decay is an international enterprise.
- ◆ Funding agencies representatives from Canada, France, Germany, Spain, United Kingdom, and the U.S. (DOE and NSF) are working to establish a framework for continued coordination.

Three proposed technologies:

- ◆ Scintillating bolometry (CUPID, ^{100}Mo enriched Li_2Mo_4 crystals)
- ◆ **Enriched ^{76}Ge crystals (LEGEND-1000, drifted charge, point contact detectors) - 1st priority for NP support**
- ◆ Liquid Xenon TPC (nEXO, light via SiPM, drifted ionization)



Office of Science Advisory Committee Charges

Facilities of the Future Charge

- Review proposed facilities and upgrades, identify any gaps, and prioritize the facilities that are most crucial to the needs of the nation for the next ten years (2026-2036)
- Consider how proposed facilities integrate with and support the Genesis Mission for AI and QIS, as well as other Administration priorities in fusion, microelectronics, biotechnology, and discovery science

AI for Transformative Science Charge

- Identify how to prioritize SC resources to accelerate the application of AI for transformative scientific and engineering discovery focused on pressing national science and technology challenges
- Create a decadal roadmap articulating near, mid, and long-term priorities for SC to achieve the Genesis Mission

Quantum Computing Roadmap Charge

- Create a roadmap to identify near-term steps to a concrete 2028 goal of an error-corrected quantum computer capable of revolutionary science
- Assess current landscape, noting technical opportunities, gaps, and public-private partnerships to leverage impact

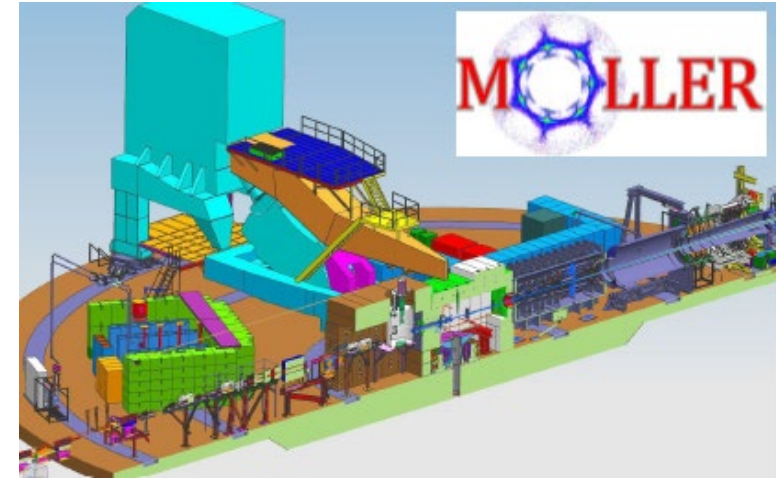
Status of other MIE projects

Gamma Ray Energy Tracking Array (GRETA)
for FRIB, ATLAS (LBNL)



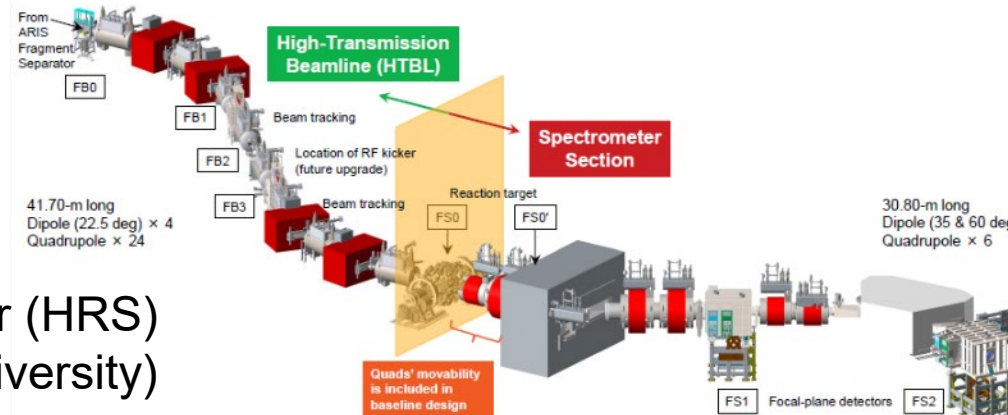
Fully funded and delegated: Approved for early science

Measurement of a Lepton-Lepton
Electroweak Reaction (MOLLER) for CEBAF



Fully funded: CD-2/3 achieved May 2024

High Rigidity Spectrometer (HRS)
for FRIB (Michigan State University)



2 subprojects – Spectrometer plus
High-Transmission Beamline (HTBL)

HTBL CD-2/3 achieved Feb 2025

NP user facilities provide critical capabilities to maintain U.S. scientific leadership

- Access to three accelerator-based facilities for exploring nuclear matter in all forms
 - **Facility for Rare Isotope Beams** and **Argonne Tandem Linac Accelerator System** study how protons and neutrons combine to form the atomic nucleus.
 - **Continuous Electron Beam Accelerator Facility** seeks to understand quarks and gluons, the elementary building blocks of protons and neutrons.
- Open to all scientists, this suite of facilities forms the backbone of the nation's nuclear physics research infrastructure.
- Over 4,000 users from the scientific community access these facilities annually.
- **Relativistic Heavy Ion Collider** ended operation in FY 2026 – support continues for users to analyze data and for hadron injector operations for isotopes and microelectronics testing missions.

RHIC@BNL



ATLAS@ANL



FRIB@MSU



CEBAF@TJNAF



HEP: User Facilities



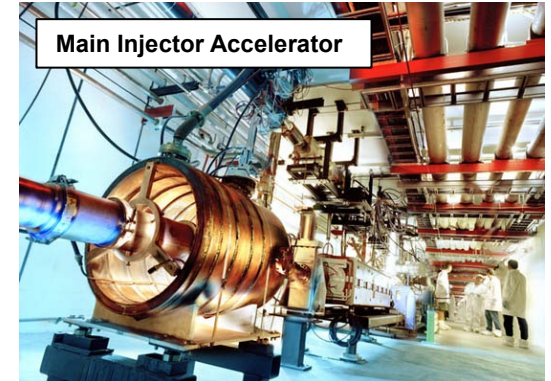
Fermilab Accelerator Complex

- Enabling cutting-edge muon and neutrino experiments with optimized operations and advanced technologies like AI/ML.
- Integrating PIP-II and commissioning Mu2e
- Renewing mission critical infrastructure to ensure robust accelerator, beamline, detector, and computing capabilities.
- Supporting beam operations prior to long shutdown, and accelerator maintenance and updates necessary to prepare the complex for LBNF/DUNE.



SLAC FACET-II

- Electron beam-driven plasma wakefield acceleration facility, integrating AI/ML for improved beam control and experimental performance.
- Completing current advanced accelerator research program.



BNL ATF

- Accelerator test facility delivering unique accelerator test capabilities for users.
- Integrating and testing AI/ML for efficient operations.



HEP: Additional Facility Operations



Sanford Underground Research Facility

- South Dakota Science and Technology Authority (SDSTA) cooperative agreement which supports basic services and critical infrastructure
- Future home of the DUNE far detectors still under construction, and current location to a variety of underground science including dark matter, geology, and biology.
- Funding will support ongoing modernization efforts.



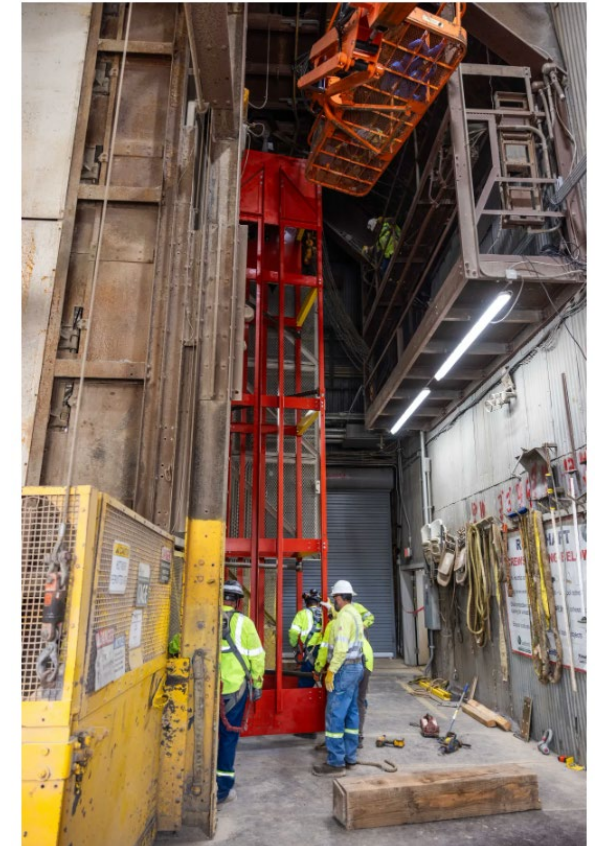
NSF-DOE Vera C. Rubin Operations

- DOE and NSF jointly operate the Rubin Observatory in Chile, with SLAC managing DOE's responsibilities, including the U.S. Data Facility that processes and serves data to researchers, the world's largest 3.2-gigapixel LSST Camera, and top management roles.
- Rubin is moving towards steady-state operations in its 2nd year. AI/ML will optimize efficiency and discoveries in dark energy research.



U.S. LHC Detector Operations


- Supports the maintenance of U.S.-supplied components of the ATLAS and CMS detectors at CERN, and the U.S.-based computer infrastructure used to analyze LHC data.

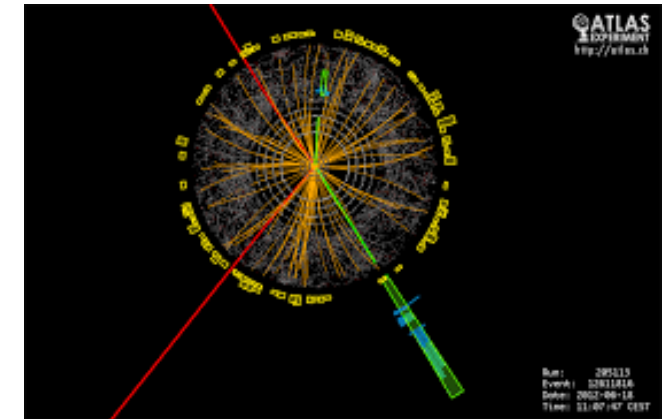
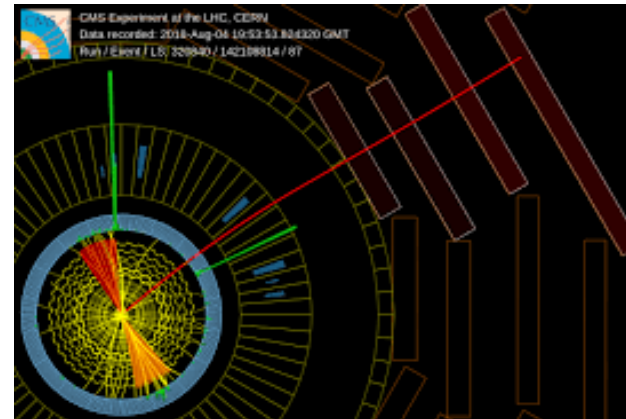
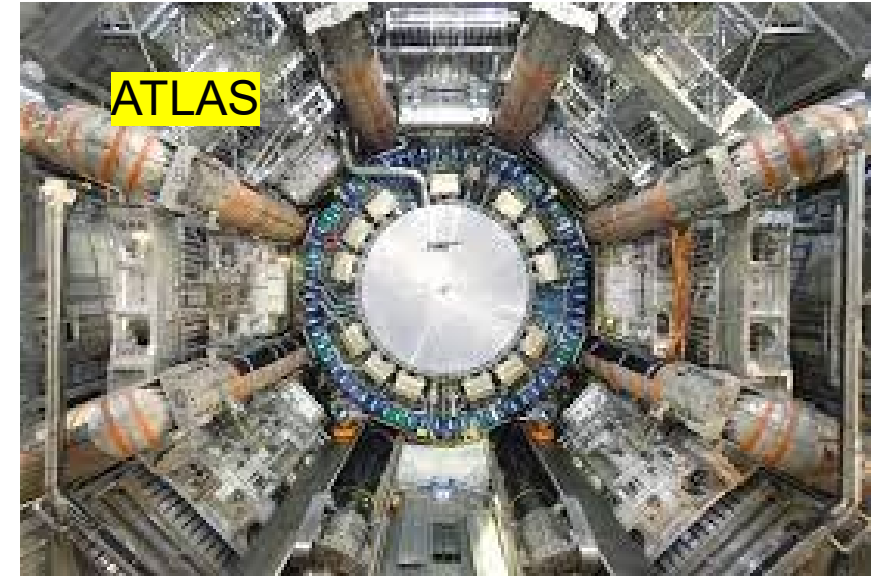
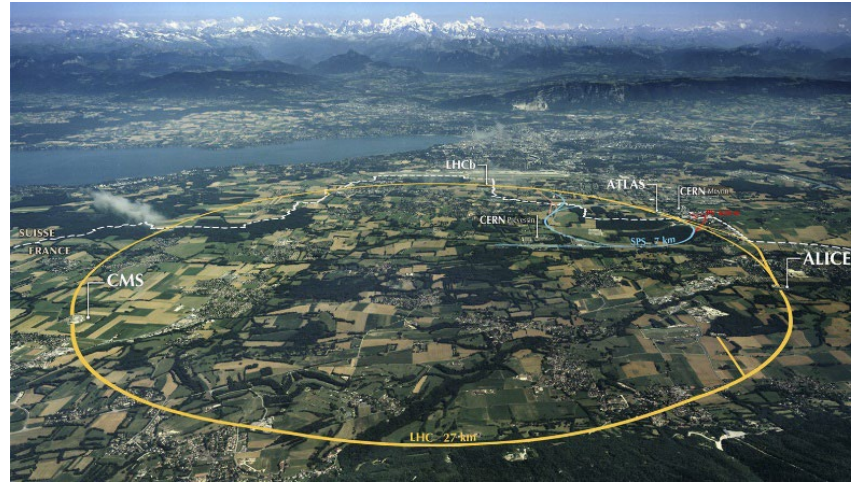


A 60-foot-high skip cage was installed at SURF to transport 45-foot steel I-beams 4850 feet underground for the DUNE experiment. These beams form part of DUNE's five-story cryogenic detectors, designed to hold 17,000 metric tons of super-chilled liquid argon, with all components needing to fit the shaft's limited dimensions.



Energy Frontier: Large Hadron Collider experiments

	Energy Frontier	Intensity Frontier	Cosmic Frontier
Higgs Boson	●		
Neutrino Mass		●	●
Dark Matter	●	●	●
Cosmic Acceleration			●
Explore the Unknown	●	●	●



Intensity Frontier Experiments

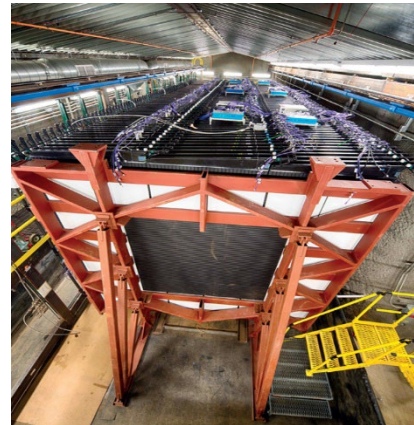
	Energy Frontier	Intensity Frontier	Cosmic Frontier
Higgs Boson	●		
Neutrino Mass		●	●
Dark Matter	●	●	●
Cosmic Acceleration			●
Explore the Unknown	●	●	●



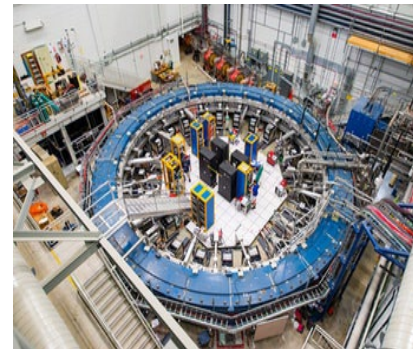
ICARUS at Fermilab



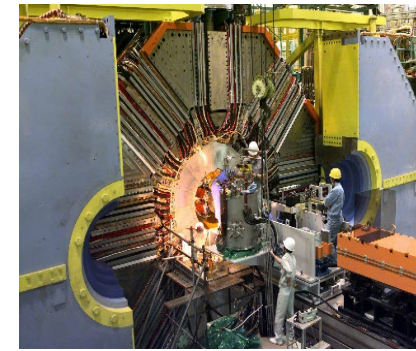
Mu2E at Fermilab



NOvA at Fermilab and Ash



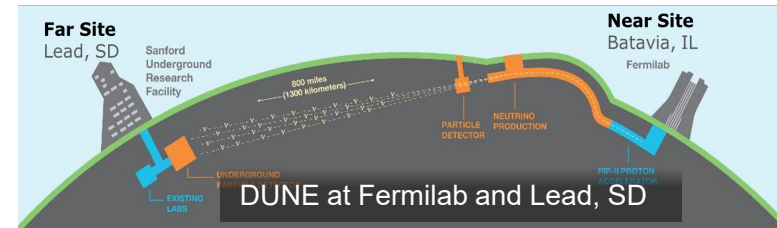
Muon g-2 at Fermilab



Belle II at KEK, Japan



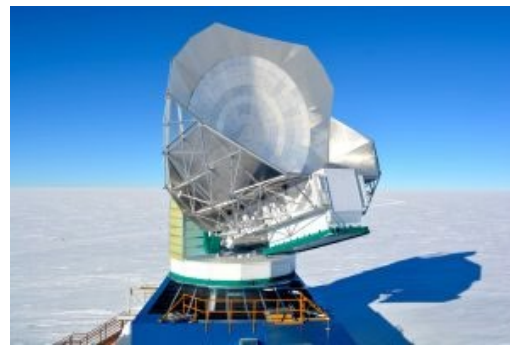
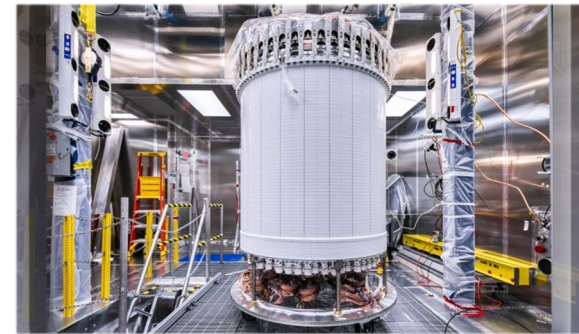
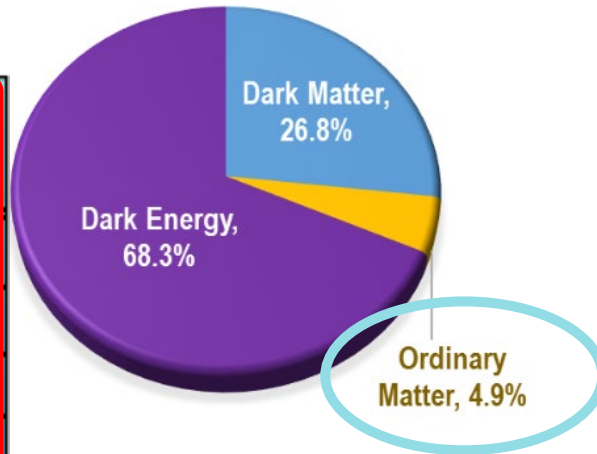
COHERENT at ORNL



Cosmic Frontier Experiments

Cosmic Frontier experiments address four of five science drivers. They use naturally occurring sources to determine the fundamental nature of matter, energy, space and time.

	Energy Frontier	Intensity Frontier	Cosmic Frontier
Higgs Boson	●		
Neutrino Mass		●	●
Dark Matter	●	●	●
Cosmic Acceleration			●
Explore the Unknown	●	●	●



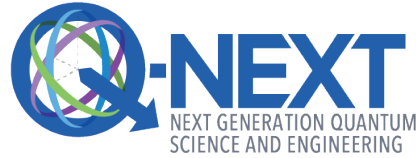
Partnerships w/NSF (PHY, AST, OPP) NASA (AST, ISS, CLPS)



HEP in Quantum Information Science



SUPERCONDUCTING QUANTUM MATERIALS & SYSTEMS CENTER

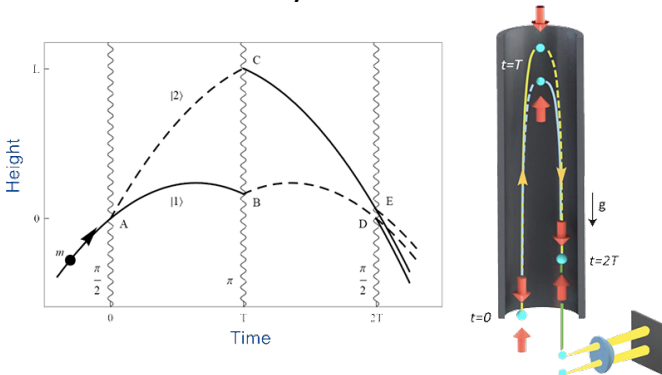


National QIS Research Centers:

- **SQMS (Fermilab):** Developing superconducting quantum technologies for scalable computing and HEP-specific sensing and computing targets.
- **Q-NEXT (Argonne):** Quantum networking and integration across heterogeneous devices; applying entanglement-enhanced sensing across a range of distances for gravitational physics.

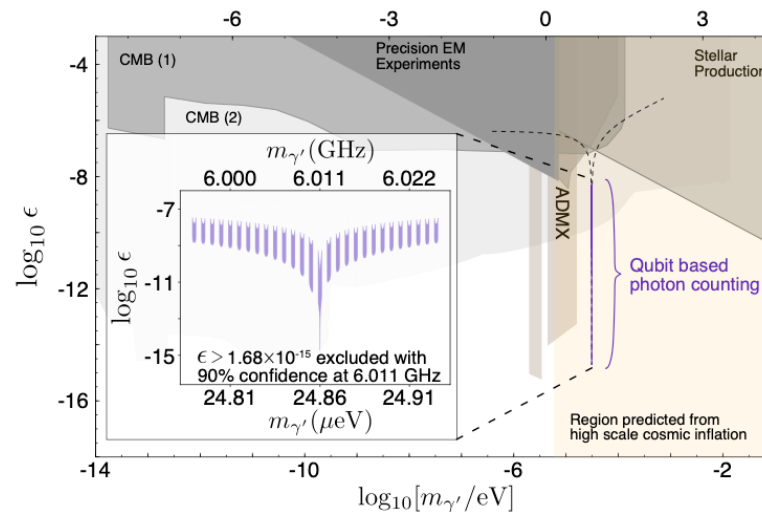
MAGIS-100

Sensing. World record search for dark photon dark matter using qubit readout to reduce noise nearly 16 dB below SQL



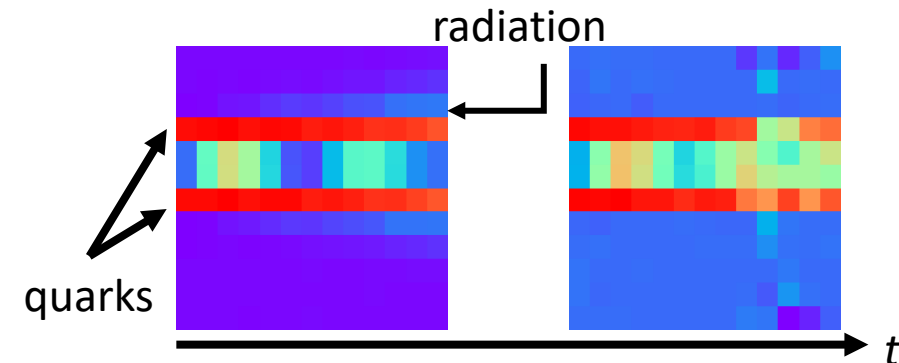
Building and operating a world-record 100m atomic interferometer at Fermilab enabling new dark matter and gravitational wave searches.

Quantum Information Science Enabled Discovery (QuantISED)



A. V. Dixit, et al., Phys.Rev.Lett. 126 (2021) 14, 141302

Computing. Simulation of radiating meson in a 1+1D lattice; new computational methods reducing estimated quantum resources required by as much as 10^{19} (arXiv:2503.11888).



(Left) Classical and (right) quantum [104 qubits, IBM Heron] simulation of a radiating meson in a 1+1D lattice.

Phys. Rev. D 111, 054501



NP in Quantum Information Science



Supports one of SC's National QIS Research Centers

- Led by BNL, partners with IBM, PNNL, and 25 other institutions to build tools for scalable fault-tolerant quantum systems
- >350 team members, 5 subject inventions, 11 open-source packages, 173 publications

NP QIS Highlights:

- **Quantifying background radiation on qubits.** Scientists used a thermal kinetic inductance detector to measure disruptive events that were consistent with known terrestrial and cosmic sources of radiation. Such measurements are crucial to deduce the impact on coherence times of qubits that are subject to naturally occurring radiations.
- **Scalable quantum circuits.** Scientists at the InQubator for Quantum Simulations performed the one of the largest quantum simulations to date (more than 100 qubits) using IBM's quantum computers. The results from the quantum computer address the need for complex simulations of pre-collisional protons and heavy nuclei.
- **Detecting the decay of individual nuclei.** Scientists detected the decay of radioactive lead-212 embedded in helium by measuring the recoil of the helium atom. This was identified as a 2024 top 10 breakthrough by Physics World and demonstrates that very small forces (10^{-20} N) and accelerations (10^{-7} g) are in the realm of detection.



Genesis Mission and High Energy Physics

- HEP's unique expertise plays a key role in the Genesis Mission
 - **The Genesis Mission Platform:** integrate cutting edge technologies in experiment's large collaborative efforts and partner to ensure the computing ecosystem can deliver HEP discovery science
 - As Infrastructure Partners use experience to further AI and ML tools along the road to widespread deployment
 - Through Pilot Intelligent Data Activities curate AI-ready content
 - Through Seedling Model Teams develop AI tools that can be fundamental constituents of the universe
 - **Genesis Mission National Challenges:** HEP is advancing emerging technologies and fundamental science of national interest:
 - Discovering Quantum Algorithms with AI
 - Realizing Quantum Systems for Discovery
 - Recentering Microelectronics in America
 - Enhancing Particle Accelerators for Discovery
 - Unifying Physics from Quarks to the Cosmos



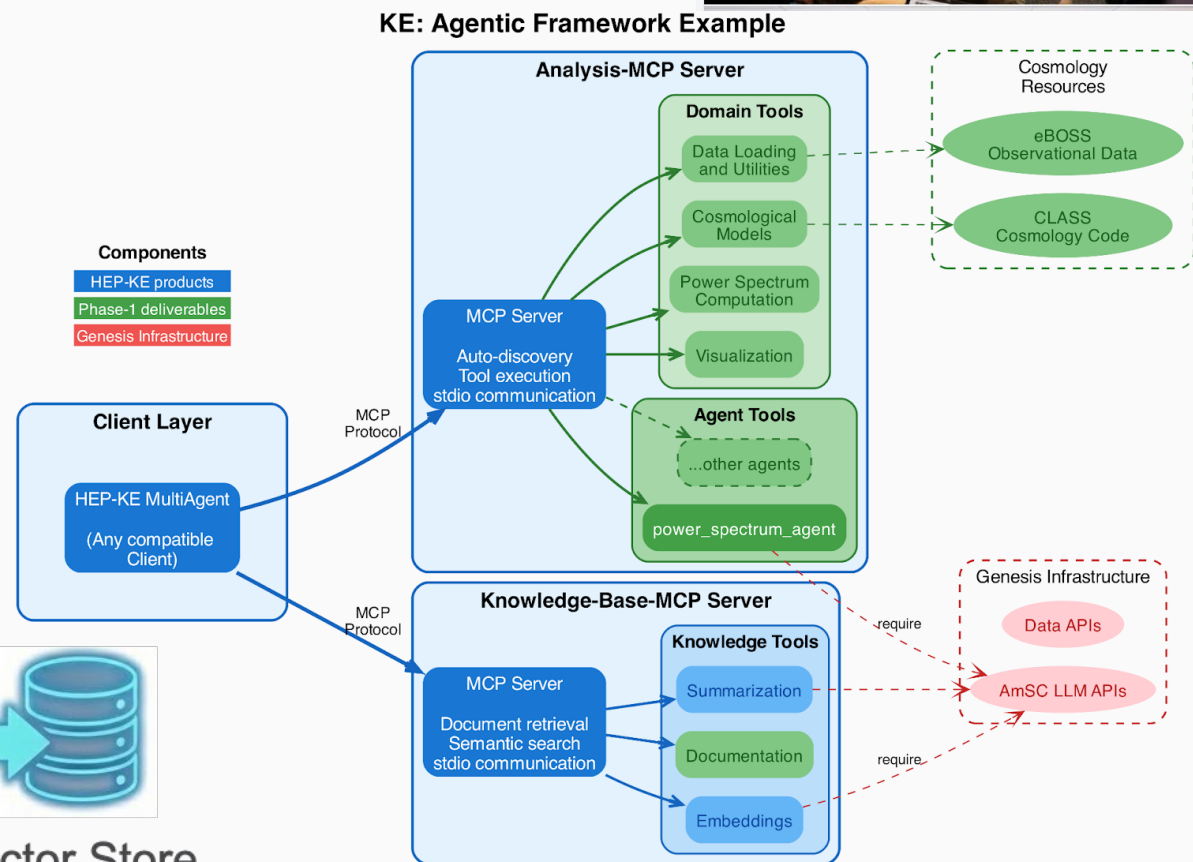
Documents

Text Extraction

Chunking

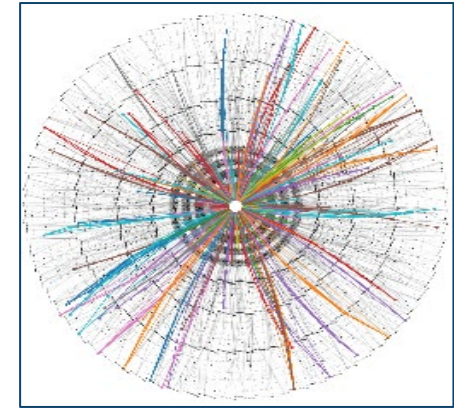
Embedding

Vector Store

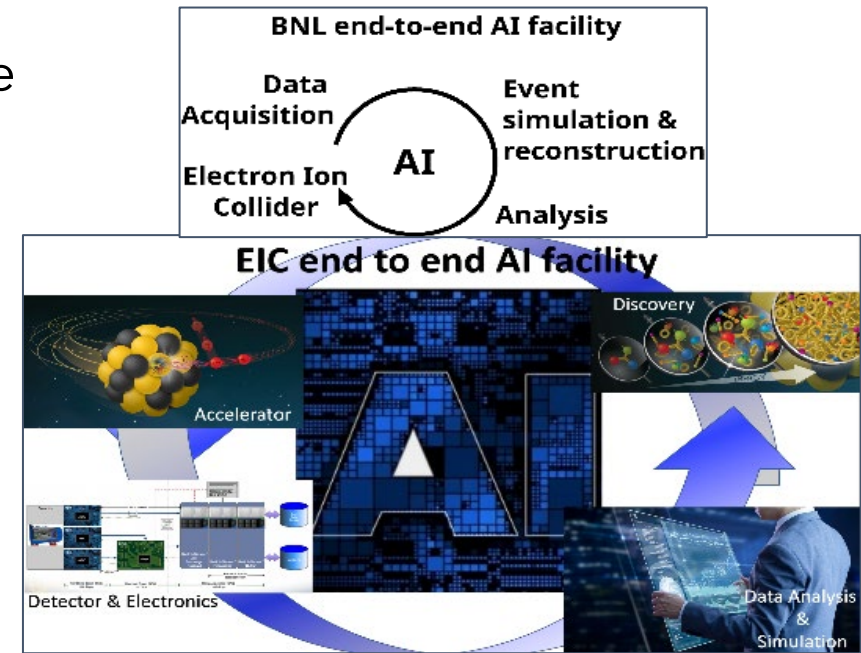


Genesis Mission and Nuclear Physics

- ◆ Coordinating with ASCR, HEP, and other SC programs, **NP is advancing its mission through the development of AI-ready datasets and AI models that can take advantage of them.**
- ◆ Two discovery science national challenges targeted:
 - Unifying Physics from Quarks to the Cosmos
 - Enhancing Particle Accelerators for Discovery
- ◆ While the NP community has actively employed AI methods, the Genesis Mission offers a unique opportunity to overcome workflow pinch points and synthesize data from disparate domains.
- ◆ The development of domain-specific data standards and metadata for multi-modal data, including expert knowledge documentation, **will feed the American Science Cloud (AmSC)**, using the power of AI to accelerate **discovery of new physics** and progress on the fundamental questions on the nature of nuclear matter.



Event Reconstruction with Geometric Deep Learning



HENP Summary

- The HEP and NP programs focus on answering the most fundamental questions about matter, energy, space and time.
- We do this by building and operating state-of-the-art facilities and instruments, collecting and analyzing large, complex data sets and publishing scientific results. Facility operations and data processing continue to be enhanced by the application of AI tools.
- Both programs have been guided by planning processes that evaluate the science and sets priorities such that the focus remains centered on answering the most pressing and compelling questions.
 - Budget realities have not matched outyear scenarios, making it challenging to execute the vision set out in the plans
 - HEP and NP are executing a portfolio of projects launched this decade and should have construction completed within the coming decade, setting us up for producing record breaking quantities of data and world leading results for decades to come.
- The synergies between HEP and NP will enable a smooth transition in support of the SC realignment.

